

U.S. DEPARTMENT OF COMMERCE PATENT & TRADEMARK OFFICE

B/O Form PTO-1390	Transmittal Letter to the United States Designated/Elected Office (DO/EO/US) Concerning a Filing Under 35 USC 371	Attorney's Docket Number ARIL3001/REF U.S. Application Number (if known) 09/787902
International Application Number PCT/NO99/00299		International Filing Date 30 September 1999 Priority Date Claimed 30 September 1998
Title of Invention PRODUCTION OF HYDROGEN AND CARBON WITH A CARBON BLACK CATALYST		
Applicant(s) for DO/EO/US Vik ARILD		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items under 35 USC 371:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 USC 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371.
3. ☒ This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed 35 USC 371(c)(2).
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 USC 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 USC 371(c)(4)). (☐ Executed ☐ Unexecuted)
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).

Items 11 to 16 below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☐ Other items or information:

Application Number (if Known) 09/787902		International Application Number PCT/NO99/00299		Attorney's Docket Number ARIL3001/REF	
				Calculations	PTO USE ONLY
17. The following fees are submitted: Basic National Fee (37 CFR 1.492(a)(1)-(5)): <input type="checkbox"/> Search report has been prepared by the EPO or JPO \$860.00 <input type="checkbox"/> International Preliminary Examination Fee paid to USPTO (37 CFR 1.482) \$690.00 <input type="checkbox"/> No International Preliminary Examination Fee paid to USPTO (37 CFR 1.482) but International Search Fee paid to USPTO (37 CFR 1.445(a)(2)) \$710.00 <input checked="" type="checkbox"/> Neither International Preliminary Examination Fee (37 CFR 1.482) nor International Search Fee (37 CFR 1.445(a)(2)) paid to USPTO \$1000.00 <input type="checkbox"/> International Preliminary Examination Fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00				\$1,000.00	
ENTER APPROPRIATE BASIC FEE AMOUNT				\$ 1,000.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).					
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	13 -20 =	0	× \$18.00	\$ 0.00	
Independent Claims	4 -3 =	1	× \$80.00	\$ 80.00	
Multiple Dependent Claims (if applicable)			+ \$270.00		
TOTAL OF ABOVE CALCULATIONS				\$ 1,080.00	
Reduction by ½ for filing by small entity, if applicable. Small Entity Status is asserted pursuant to 37 CFR 1.27 for this application.					
SUBTOTAL					
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).					
TOTAL NATIONAL FEE					
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property.					
TOTAL FEES ENCLOSED				\$ 1,080.00	
				Amount to be:	Refunded:
					Charged:

- a. ☒ A check in the amount of **\$1,080.00** to cover the fees is enclosed.
- b. ☐ Please charge my **Deposit Account Number 02-0200** in the amount of \$_____ to cover the above fees.
A duplicate copy of this sheet is enclosed.
- c. ☐ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to **Deposit Account Number 02-0200**. A duplicate copy of this sheet is enclosed.

Note: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

BACON & THOMAS, PLLC
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DATE: March 29, 2001

Respectfully submitted,

Richard E. Fichter

Richard E. Fichter
 Attorney for Applicant
 Registration Number: 26,382

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reaction chamber where the carbon molecules from the gas can attach to the catalytic particles causing growth of these to a pre-set size that can be mechanically trapped.

6. (New) A method as claimed in claim 5 characterised by crushing a controlled amount of precipitated carbon and returning the crushed carbon to the reaction chamber in a continuous process for maintenance of an optimum balance with regard to the amount and size distribution of carbon particles.

7. (New) A method as claimed in claim 5 comprising heating said reaction chamber using excess heat from another high temperature process.

8. (New) A method as claimed in claim 5 comprising heating said reaction chamber to a temperature of between 300 and 2000°C.

9. (New) A method of pyrolysis of an organic gas comprising passing said gas through a heated reaction chamber containing carbon dust such that carbon from said gas is caused to precipitate onto said carbon dust.

10. (New) Apparatus for producing hydrogen and carbon in a closed process by pyrolysis of an organic gas utilising carbon dust as a catalyst for precipitation of carbon, said apparatus containing a thermally insulated reaction chamber containing said carbon dust; a heater for heating said reaction chamber and a passage for passing said gas through the reaction chamber.

11. (New) Apparatus as claimed in claim 10 comprising a temperature controller for controlling the temperature of said reaction chamber.

12. (New) Apparatus as claimed in claim 10 comprising a heat exchanger for transferring heat from gas exiting said reaction chamber to gas entering the reaction chamber.

13. (New) Apparatus as claimed in claim 10 comprising a crusher for crushing precipitated carbon from the reaction chamber and returning a proportion of said crushed carbon to the reaction chamber.

14. (New) A vehicle comprising a polymer fuel cell for generating electrical power for propulsion of the vehicle, characterised in that the vehicle further comprises an apparatus as claimed in claim 10 for generating hydrogen fuel for said fuel cell.

15. (New) The application of compact pyrolysis systems in vehicles for pre-processing of natural gas, methane and other organic gases with the aim of producing hydrogen fuel for the polymer fuel cells that generates electrical power for propulsion of the vehicle.

16. (New) A method as claimed in claim 6 comprising heating said reaction chamber using excess heat from another high temperature process.

17. (New) Apparatus as claimed in claim 11 comprising a temperature controller for controlling the temperature of said reaction chamber.

REMARKS

Applicants have canceled original claims 1-4 and have added new claims 5-17 to the application to more particularly define the invention. Applicants retain all right to file a continuation or divisional application on any canceled subject matter at a later time during the prosecution of this application.

Applicants are submitting herewith a copy of the Search Report which issued on International Application No. PCT/NO99/00299, of which the present application is the U.S. national phase. All of the publications cited in the International Search Report are listed on the attached Form PTO-1449. It is Applicants' understanding that, under the procedures of the PCT, copies of the cited publications will have been supplied to the U.S. Patent Office by the International Bureau. However, the Examiner is invited to contact the undersigned attorney if additional copies are necessary or would facilitate examination of the present application.

Otherwise, the Examiner is respectfully requested to return an initialed and dated copy of the attached Form PTO-1449 to confirm that all publications listed thereon have been considered and made officially of record in the file of this application.

Applicants understand that, under the procedures of the PCT, a copy of the priority document (NO 19984560, filed 30 September 1998) will have been supplied to the U.S. Patent Office pursuant to Rule 17 of the PCT Regulations. It is therefore respectfully requested that the first Official Action in the present application contain an indication that the appropriate priority document is in the file of this application.

In view of the above amendments, an early action on the application is now in order and is most respectfully requested.

Respectfully submitted,
BACON & THOMAS, PLLC

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PRODUCTION OF HYDROGEN AND CARBON WITH A CARBON BLACK CATALYST.

The invention includes method, device and application of energy efficient production of hydrogen and carbon by pyrolysis based on natural gas, methane or other organic gases as raw material. The method for precipitation of solid carbon is characterised by the use of finely distributed carbon dust as catalyst for the precipitation process. Carbon molecules from the gas attach to the catalytic particles causing growth of these to a trappable size. The catalytic material is regenerated by continuous supply of finely crushed carbon from the process.

The device is designed as a heat insulated reaction chamber with room for the catalytic material. The temperature in the reaction zone is controlled by means of supplied energy. Heating can also take place using alternative heat sources, and the system may therefore use excessive heat from high temperature processes as energy source for the complete- or parts of the process. The device has shown good efficiency in a temperature range from 400°C to 2000°C. The reaction rate and the purity of the final products can be controlled by optimisation of pressure and temperature.

In addition the invention covers the application of compact pyrolysis systems for use in vehicles, for pre-processing of gasses containing hydrocarbons and for fuel production for polymer fuel cells. The fuel cells utilise hydrogen as fuel and generate electrical power for propulsion of the vehicle. Both the pyrolysis system and the fuel cells can be designed compactly to fit ordinary vehicles.

The device and method is particularly well suited in environments with limited supply of hydrogen and oxygen, but with good energy supplies. An example of such environments is the vehicles and units that operate outside the earth's atmosphere.

Chemically clean carbon (carbon black) has been an important industrial product for many years. Large quantities are used in the production of car tires. The material is also used in paint products, in lubricants and in medical products. A number of methods for production of carbon from hydrocarbon gases have been developed during a period of years. Splitting of carbon and hydrogen from such gases is currently in focus from environmental reasons in connection with natural gas based production of electrical power. Also the space industry has interest in the hydrogen production as part of the water production in manned space journeys/stations.

A known method for splitting of hydrocarbons is the use of plasma arc. This method is described in US.Pat.no. 5,527,518. Another method is described in US.Pat.no. 4,631,180. Both methods involve combustion and use oxygen in the production.

A method for splitting of hydrocarbons is described in US.Pat.no. 5,198,084. This method is used for gasification of carbon containing material, and the gas is heated by means of microwave technology in a so-called plasma reactor.

The referred methods for splitting of hydrogen and carbon from hydrocarbons utilise different heating and combustion processes in atmospheres with insufficient oxygen supply. The method according to the invention significantly differs from these techniques by utilising carbon dust as catalyst for splitting of hydrocarbons in an oxygen free environment.

A patent DD 118263 describes a method for pyrolysis where the carbon particles are used as catalyst. The particles are sent through a gas containing hydrogen which is heated to a temperature of 1000°C - 1800°C. The invention differs significantly from this by the fact that device and method is based on

stationary carbon particles contained in a compact reaction chamber. This make it possible to produce a much more compact system compared to systems with moving particles or carbon deposition on surfaces. In addition, the new method is significantly more energy effective because the pyrolysis process operates at temperatures down to 400°C.

The method and device, according to the invention, are to be used in a process system for production of hydrogen and carbon based on natural gas, methane or other organic gases as raw material. The system is shown in principle-sketch fig.1. Gas (1) containing hydro carbons is guided through a filter (2), into a heat insulated reaction chamber (3) and heated by means of electrical heating coils or excessive heat from other high temperature processes. The temperature in the reaction chamber (3) is given an increasing gradient in the direction of flow (from bottom to top) from 300 to maximum 2000°C. The reaction chamber (3) contains finely distributed carbon dust (5) that acts as catalyst for the collection of solid carbon from the gas. The carbon molecules in the heated gas attach to the carbon dust (5) in a way that causes the catalytic particles to grow. The growing carbon particles are trapped by means of a mechanical system (for example a centrifuge) in the lower parts of the reaction chamber (6), when the grain size reaches a certain level. The carbon content in the gas gets a decreasing gradient upwards in the reaction chamber (3), and the gas contains mainly hydrogen at the top (12). The hydrogen-enriched gas is guided to a separation chamber (7), where parts of the gas are separated through a membrane filter (8). The permeate fraction of the gas (9) can be optimised with regard to the purity of the hydrogen. Before storage (10) the gas is guided through a filter (11) for removal of trace constituents. The retentate fraction of the gas (12) from the separation chamber (7) is returned to the inlet side of the reaction chamber.

On its way to the trace constituents filter (11) the processed gas (9) passes through a heat exchanger (13) for pre-heating of the feed gas (1). The exchange of heat between processed and feed gas induces a reduction in the need for energy supply to the system.

Trapping of granulated carbon takes place continuously in the lower parts of the reaction chamber (6). As the catalytic particles grow and get trapped the system needs supply of new catalytic material. According to the invention, catalytic material is continuously produced by recycling, crushing (16) and injection in the upper part of the reception chamber of a controlled fraction (15) of the separated carbon (14). This recycling process maintains an optimum balance with regard to the amount and size distribution of carbon particles.

Patent claims

1. Method for production of hydrogen and carbon by pyrolysis of methane and other organic gases utilising carbon dust as catalyst for precipitation of carbon in a closed process *characterised by* the stimulation of carbon precipitation by guiding the gas through a heated reaction chamber where the carbon molecules from the gas can attach to the catalytic particles causing growth of these to a pre-set size that can be mechanically trapped.
2. Method for production of hydrogen and carbon by pyrolysis of methane and other organic gases according to claim 1 and 2 *characterised by* the crushing of a controllable amount of precipitated carbon and the return of this to the reaction chamber in a continuous process for maintenance of an optimum balance with regard to the amount and size distribution of carbon particles.
3. Device for production of hydrogen and carbon by pyrolysis of methane and other organic gases in a closed system with a heat insulated reaction chamber *characterised by* the filling of the chamber with porous carbon dust with catalytic character and the temperature control by supply of electric power or excessive heat from high temperature processes.
4. The application of compact pyrolysis systems in vehicles for pre-processing of natural gas, methane and other organic gases with the aim of producing hydrogen fuel for the polymer fuel cells that generates electrical power for propulsion of the vehicle.

[illegible]

[The following page contains extremely faint, illegible text, likely bleed-through from the reverse side of the document.]

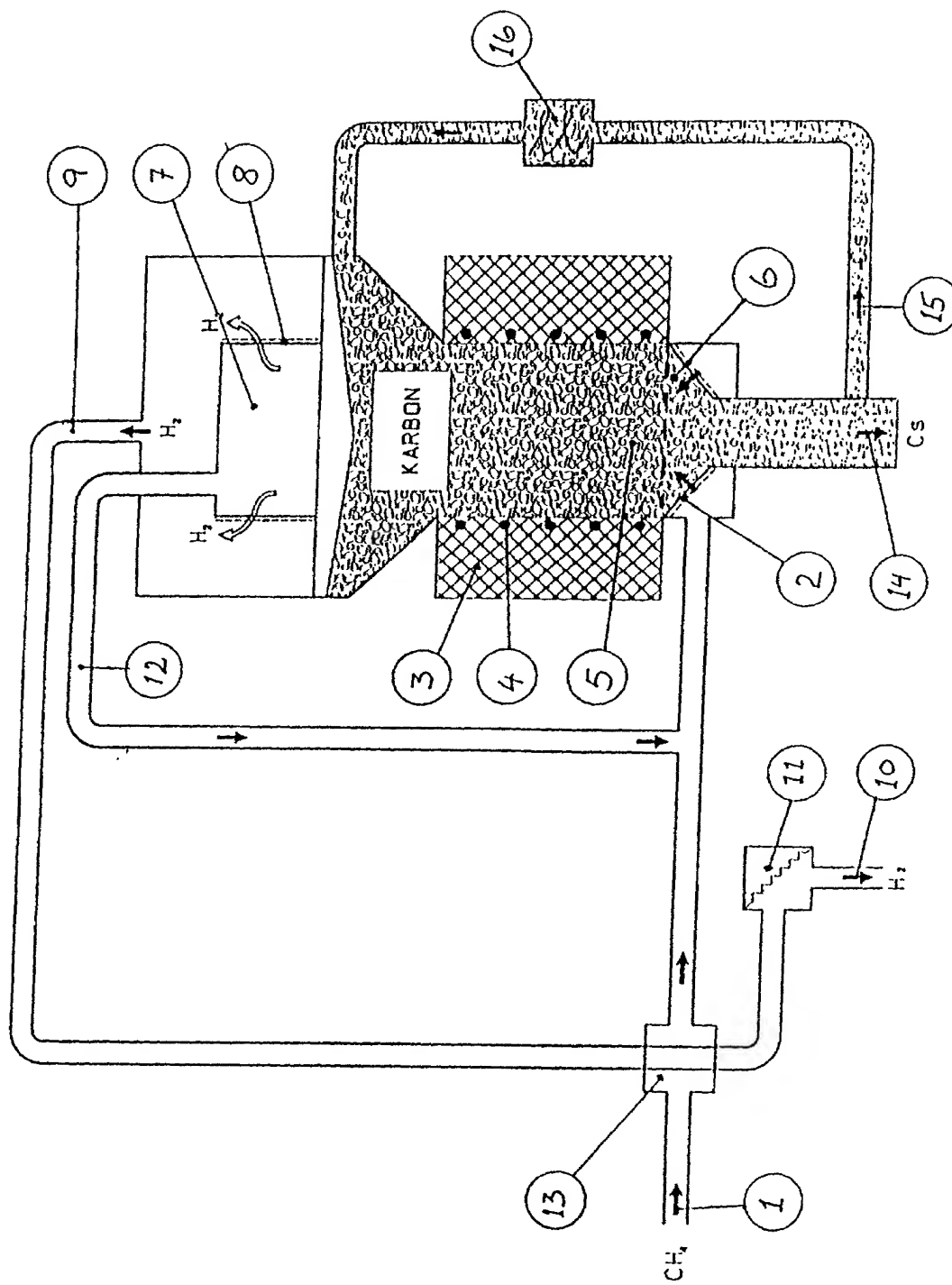


Fig. 1

DECLARATION FOR PATENT APPLICATION AND APPOINTMENT OF ATTORNEY

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name; I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention (Design, if applicable) entitled:

PRODUCTION OF HYDROGEN AND CARBON WITH A CARBON BLACK CATALYST

the specification of which (check one):

☐ is attached hereto, or ☒ was filed on: **30 September 1999** as PCT International Application Number: **PCT/NO99/00299**

and (if applicable) was amended on:

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in *Title 37, Code of Federal Regulations, §1.56*. I hereby claim foreign priority benefits under *Title 35, United States Code §119* of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

PRIOR FOREIGN APPLICATION(S)			PRIORITY CLAIMED	
Number	Country	Day/Month/Year Filed	Yes	No
19984560	NO	30 September 1998	X	

☐ Additional Priority Application(s) Listed on Following Page(s)

I HEREBY CLAIM THE BENEFIT UNDER TITLE 35 U.S. CODE §119(E) OF ANY U.S. PROVISIONAL APPLICATIONS LISTED BELOW.

Application Number	Day/Month/Year Filed

☐ Additional Provisional Application(s) Listed on Following Page(s)

I hereby claim the benefit under *Title 35, United States Code, §120* of any United States application(s) or PCT international application(s) designating The United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of *Title 35, United States Code, §112*, I acknowledge the duty to disclose information which is material to patentability as defined in *Title 37, Code of Federal Regulations, §1.56* which became available between the filing date of the prior application(s) and the national or PCT international filing date of this application:

Application Number	Filing Date	Status - Patented, Pending or Abandoned

☐ Additional US/PCT Priority Application(s) listed on Following Page(s)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under *section 1001 of title 18 of the United States Code* and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

6 POWER OF ATTORNEY: I (We) hereby appoint as my (our) attorneys, with full powers of substitution and revocation, to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: J. Ernest Kenney, Reg. No. 49,479; Eugene Mar, Reg. No. 25,893; Richard E. Fichter, Reg. No. 26,382; Thomas J. Moore, Reg. No. 28,974; Joseph DeBenedictis, Reg. No. 28,502; Benjamin E. Urcia, Reg. No. 33,805; and

I (we) authorize my(our) attorneys to accept and follow instructions from FRANK B. DEHN & CO. regarding any matter related to the preparation, examination, grant and maintenance of this application, any continuation, continuation-in-part or divisional based thereon, and any patent resulting therefrom, until I (we) or my(our) assigns withdraw this authorization in writing.

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DATE June 29th 2001	SIGNATURE Arild Vik

☐ See following page(s) for additional joint inventors.